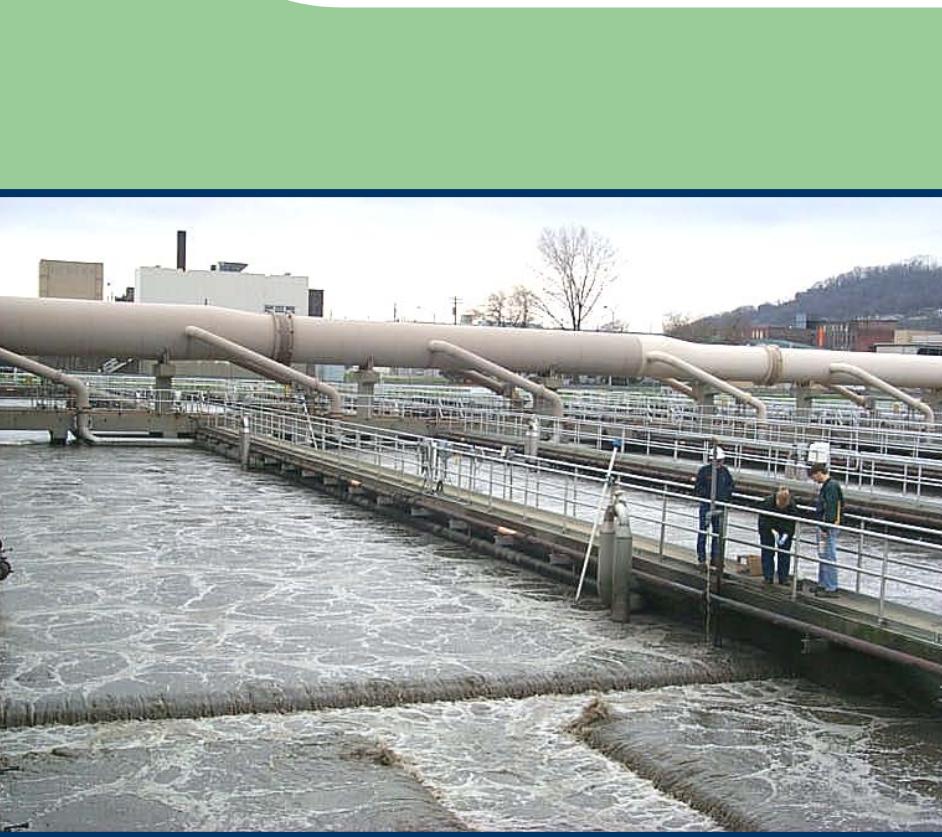


Biological Fate of Estrogenic Compounds Associated with Sewage Treatment: A Review



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Purpose

- Give you current thinking on fate of EDCs in sewage treatment systems
 - Available data
 - Qualitative discussion



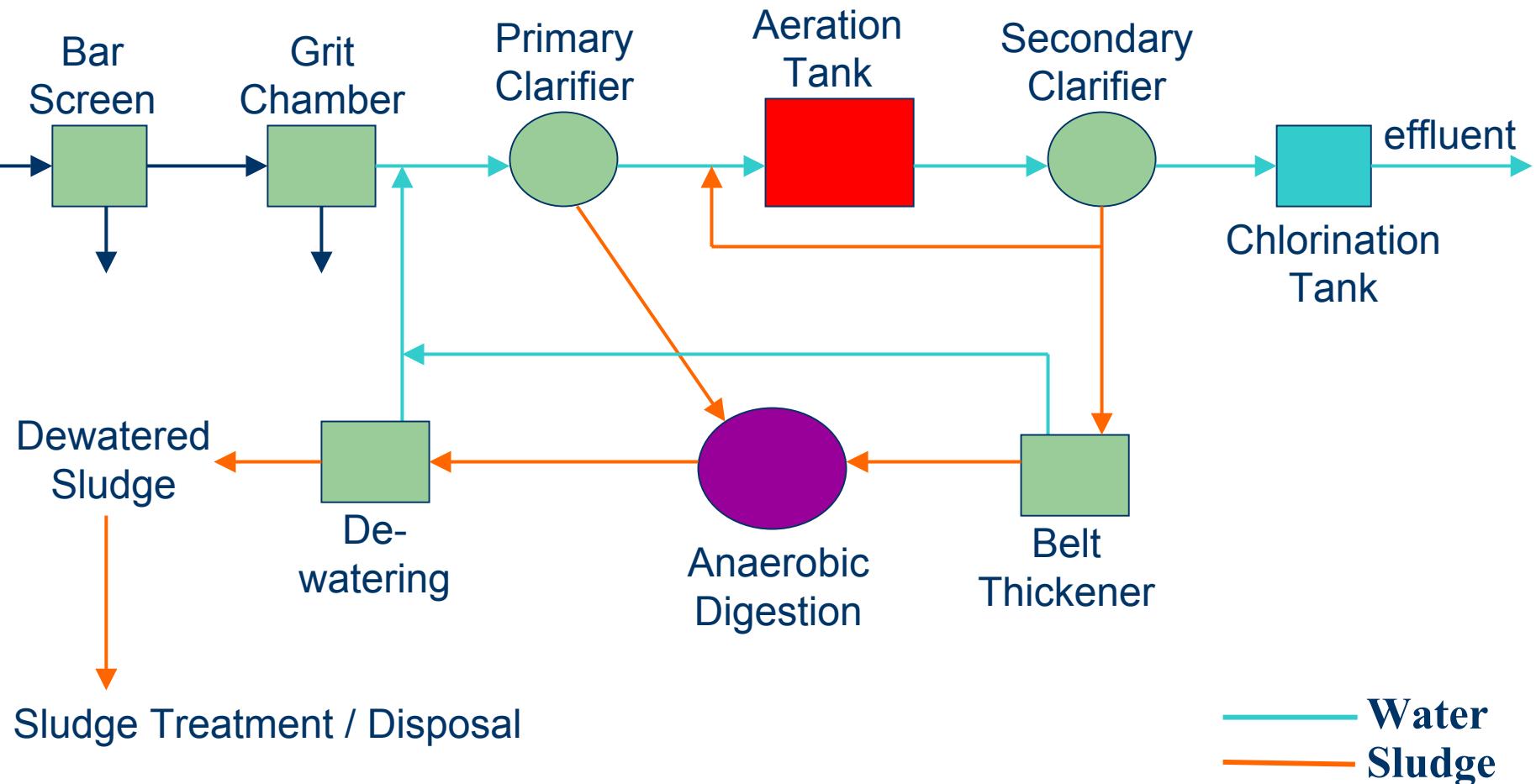
Most Prevalent Estrogenic Chemicals found in STP Effluent

- Alkylphenolic compounds
 - Biodegradation products from APE surfactants
 - Nonylphenolics
 - Octylphenolics
- Steroid hormones
 - Natural (estradiol, estrone, estriol)
 - Synthetic (ethinyl estradiol)



Typical Large STP

influent



STPs Designed for...

- BOD removal
- Suspended solids removal
- pH neutralization
- N, P removal
- Pathogen removal

Current Knowledge Limited

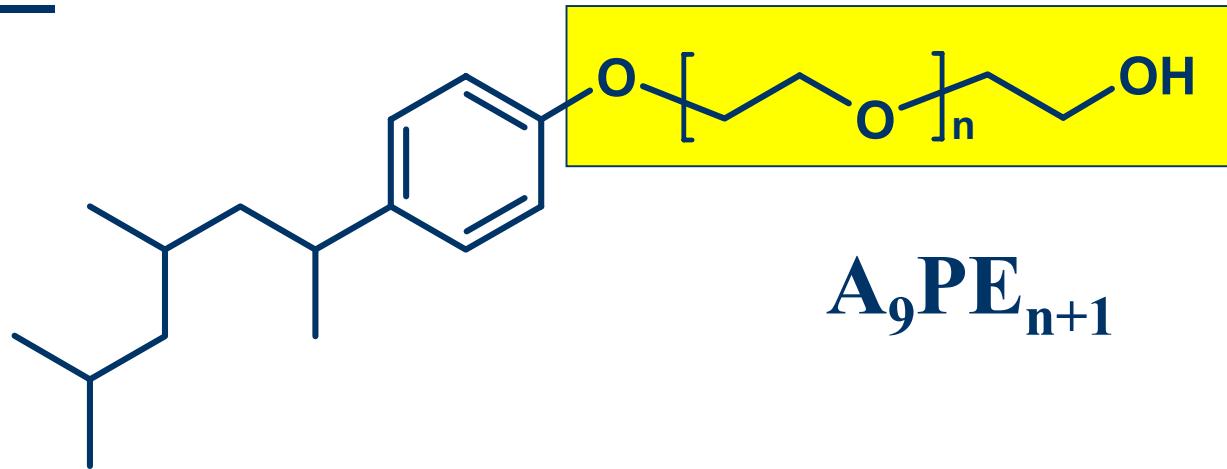
- ❖ For nonylphenolics:
 - Parent NPE are a distribution of EO units
 - > 20 isomers of the nonyl group
 - Analytical standards for NPE metabolites difficult to obtain
- ❖ For steroids and nonylphenolics:
 - Analytical methods not standardized
 - Low detection limits needed (ng/l)
- ❖ Few biodegradation studies published

NPEs - STP Influent / Raw Sewage

- ~ 500 million pounds used per year in U.S.
 - Institutional: laundry detergents, janitorial and vehicle cleaners
 - Household: cleaners and personal care products
 - Industrial: plastics, textiles and pulp and paper processing, ag chemicals
-
- Total nonylphenolics 500 – 2500 ug/l
 - Total estrogenic products 1 – 50 ug/l

Biological Transformation of APEs

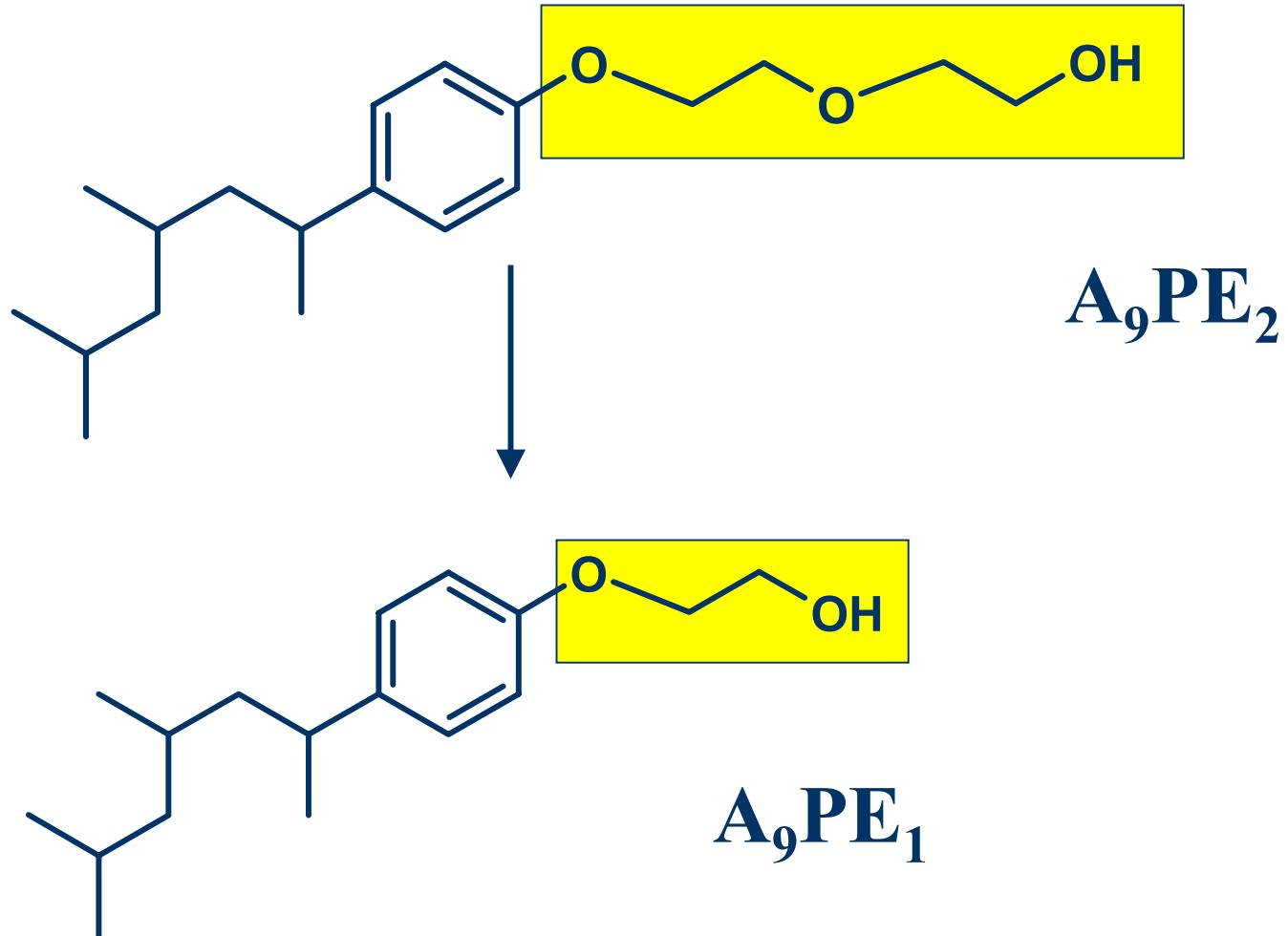
Aerobic



Parent surfactant
“nonylphenol polyethoxylate”

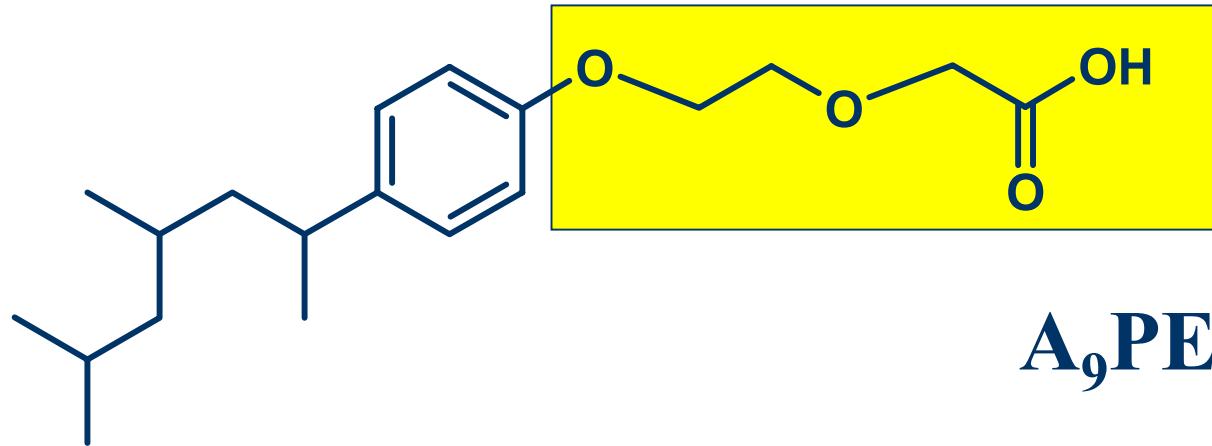
Biological Transformation of APEs

Aerobic

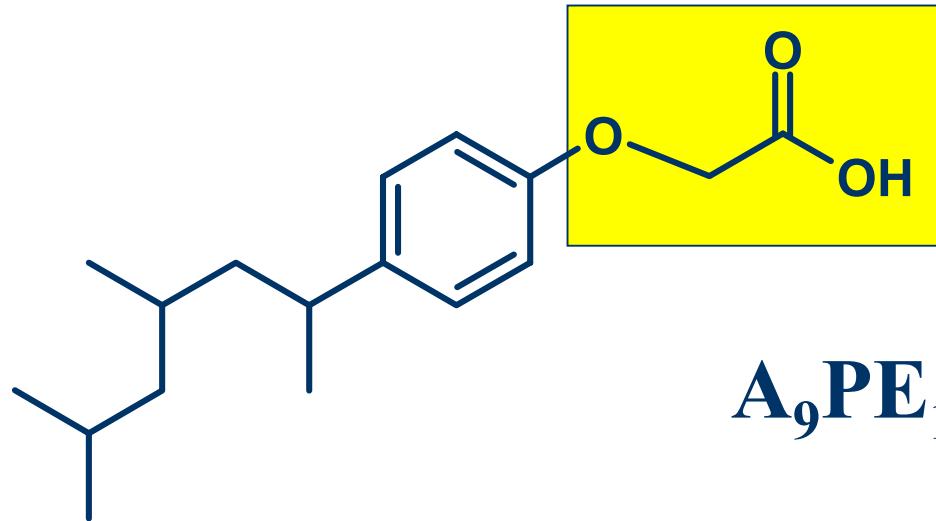


Biological Transformation of APEs

Aerobic



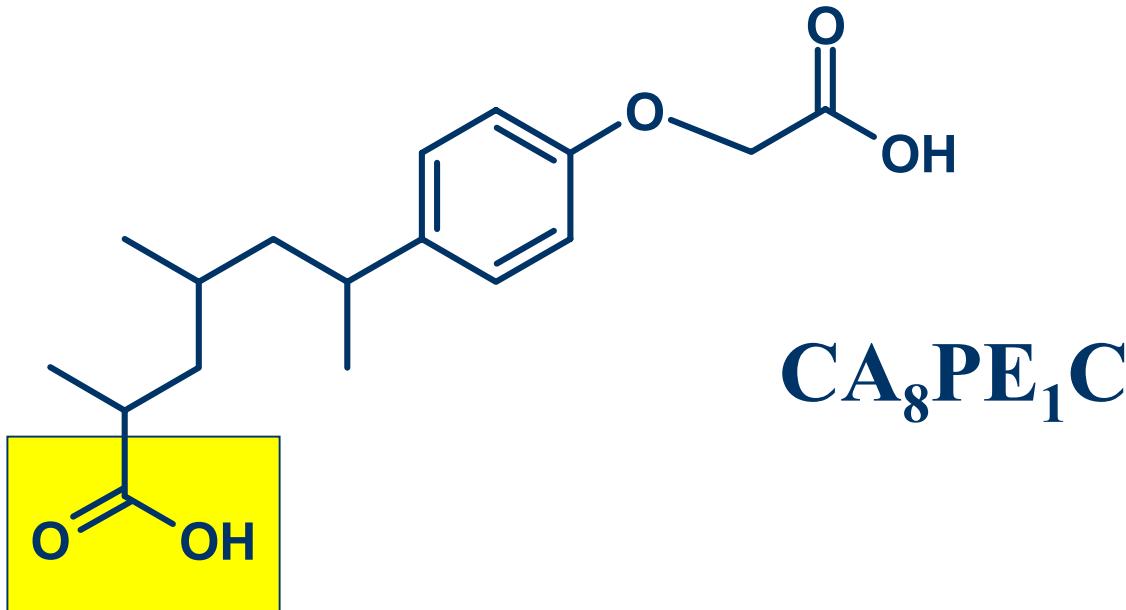
A_9PE_2C



A_9PE_1C

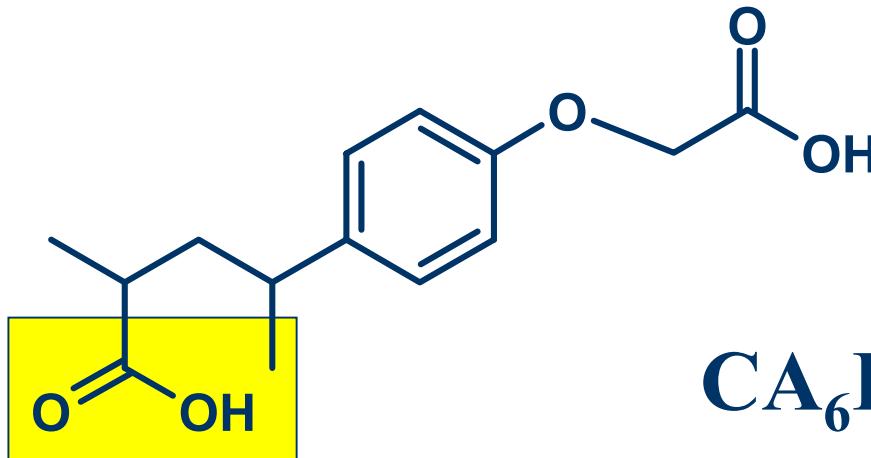
Biological Transformation of APEs

Aerobic



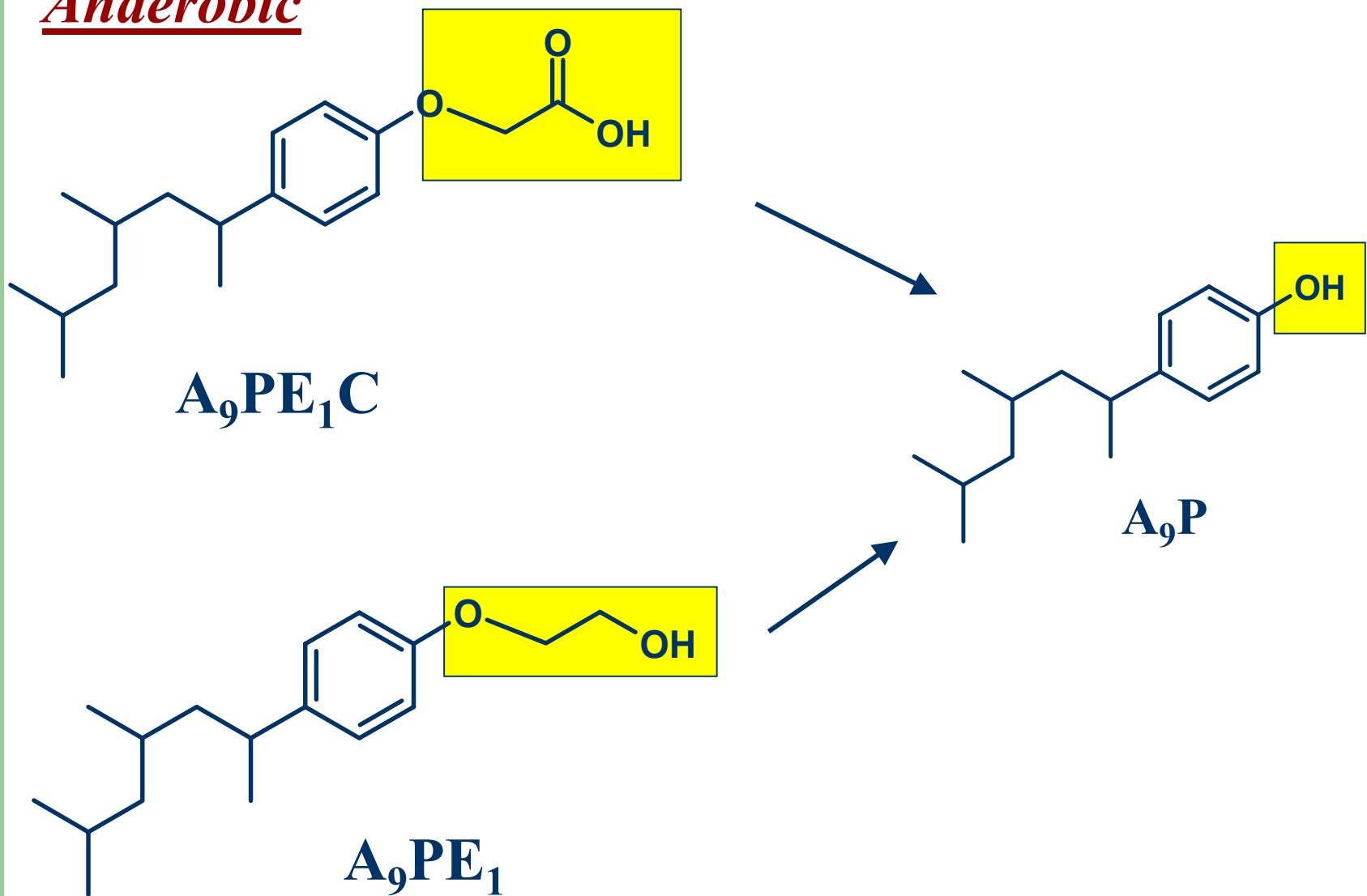
Biological Transformation of APEs

Aerobic

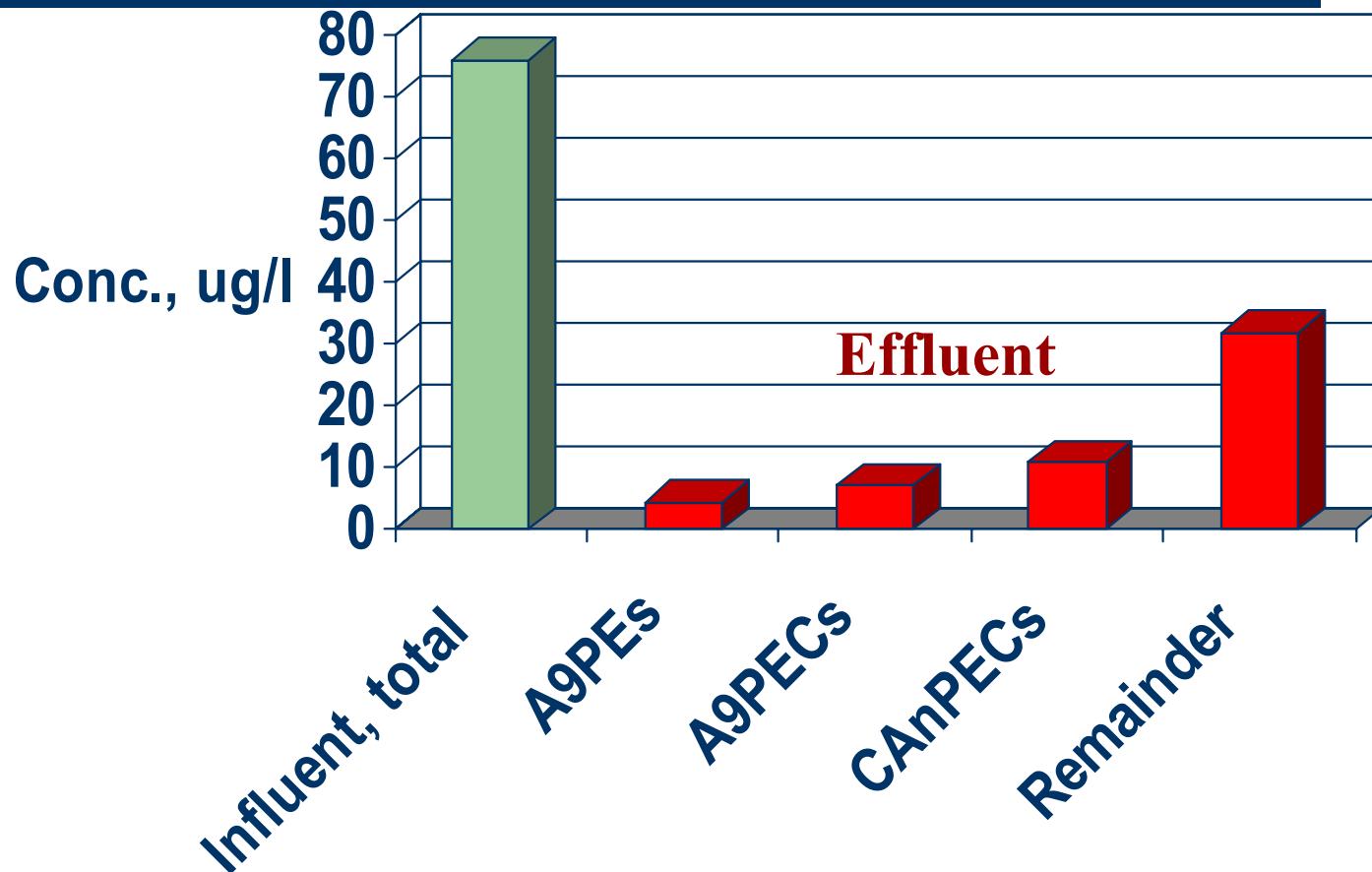


Biological Transformation of APEs

Anaerobic



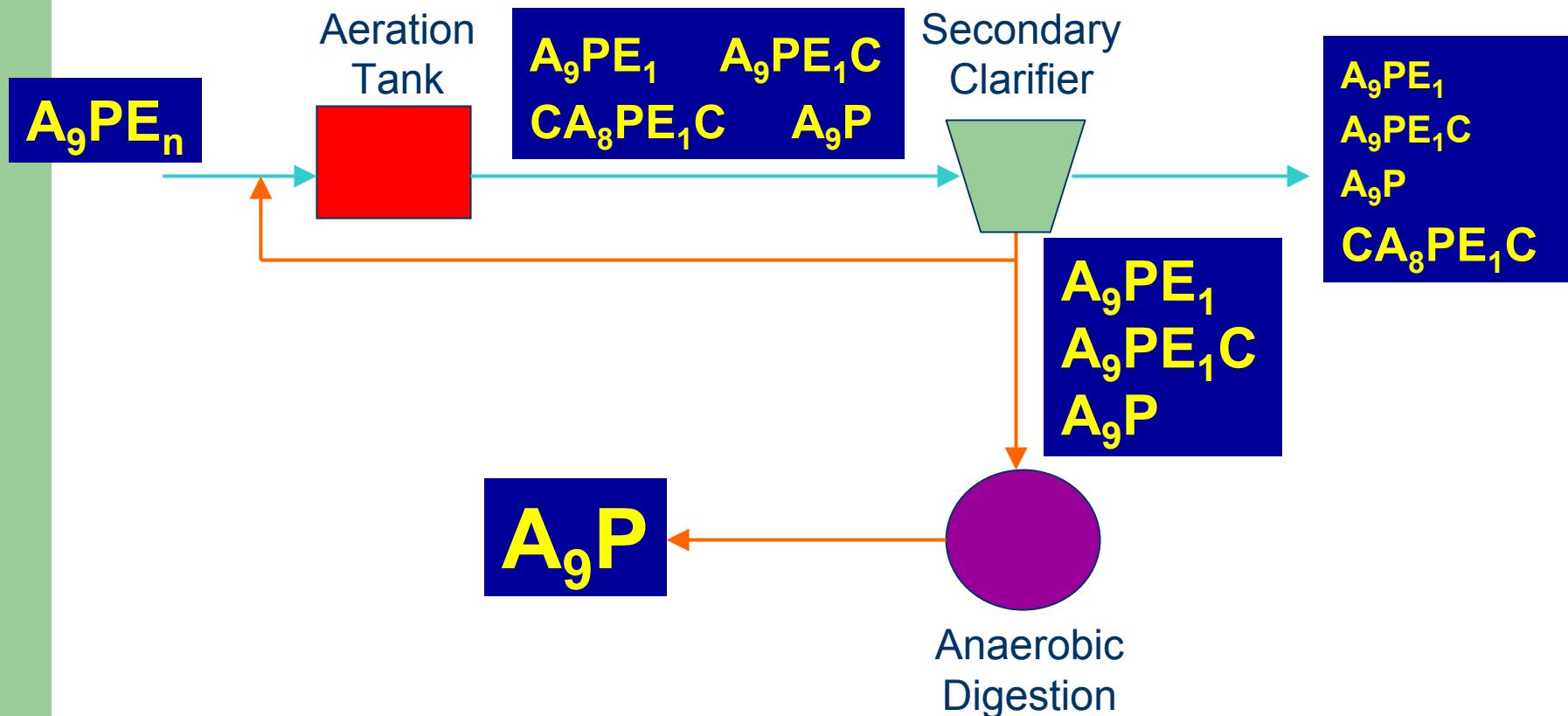
Nonylphenolic STP Balance Rome, Italy (Di Corcia, 2000)



NPE Metabolites Partition to Sludge

<u>EDC</u>	<u>log (Kow)</u>
NP	4.5
NP1EO	4.2
NP2EO	4.2
CNP1EC	<< 4

Likely Fate in STP

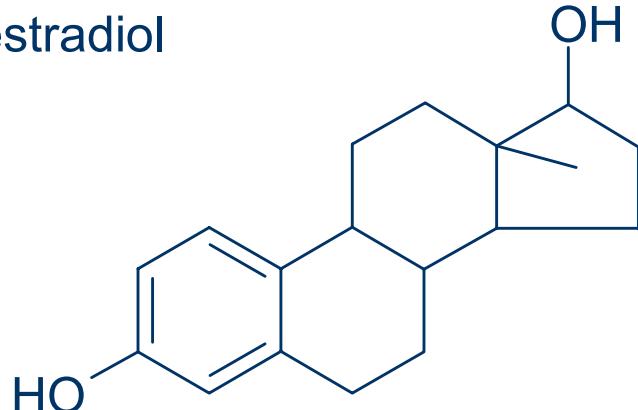


Effluent Fate

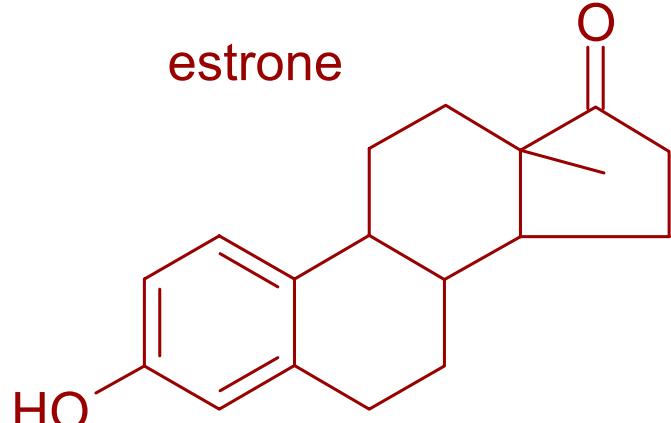
- Expect alkylphenolics in
 - Surface water (up to 20 ug/l)
 - Sludges (up to 50 mg/kg)
 - Sediments (up to 4000 mg/kg)

Influent Estrogens

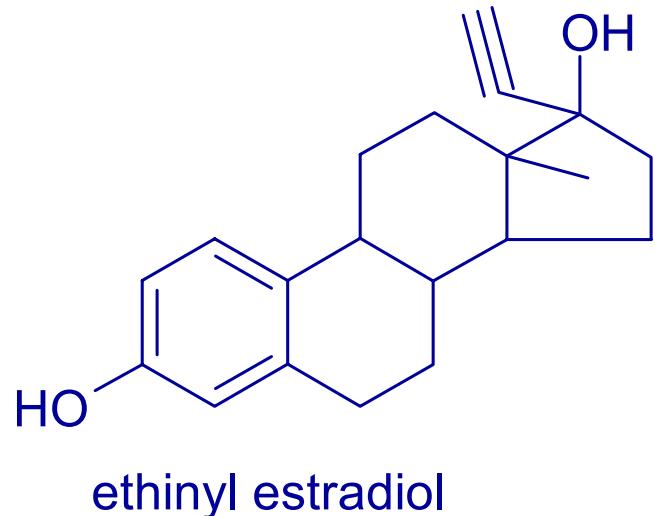
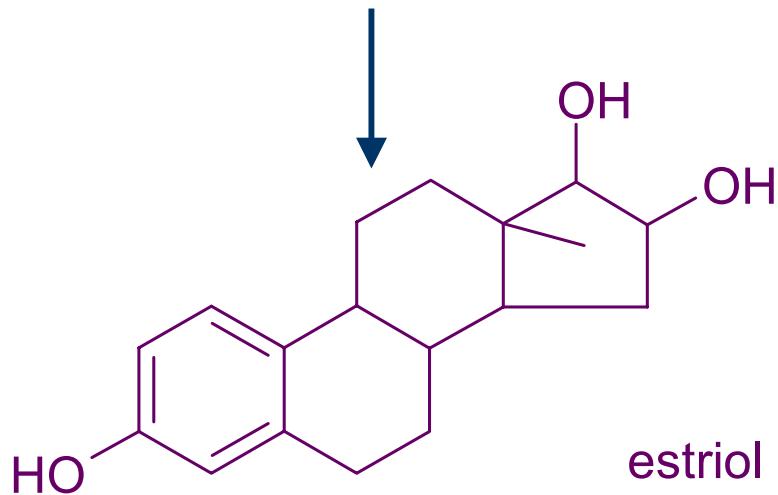
estradiol



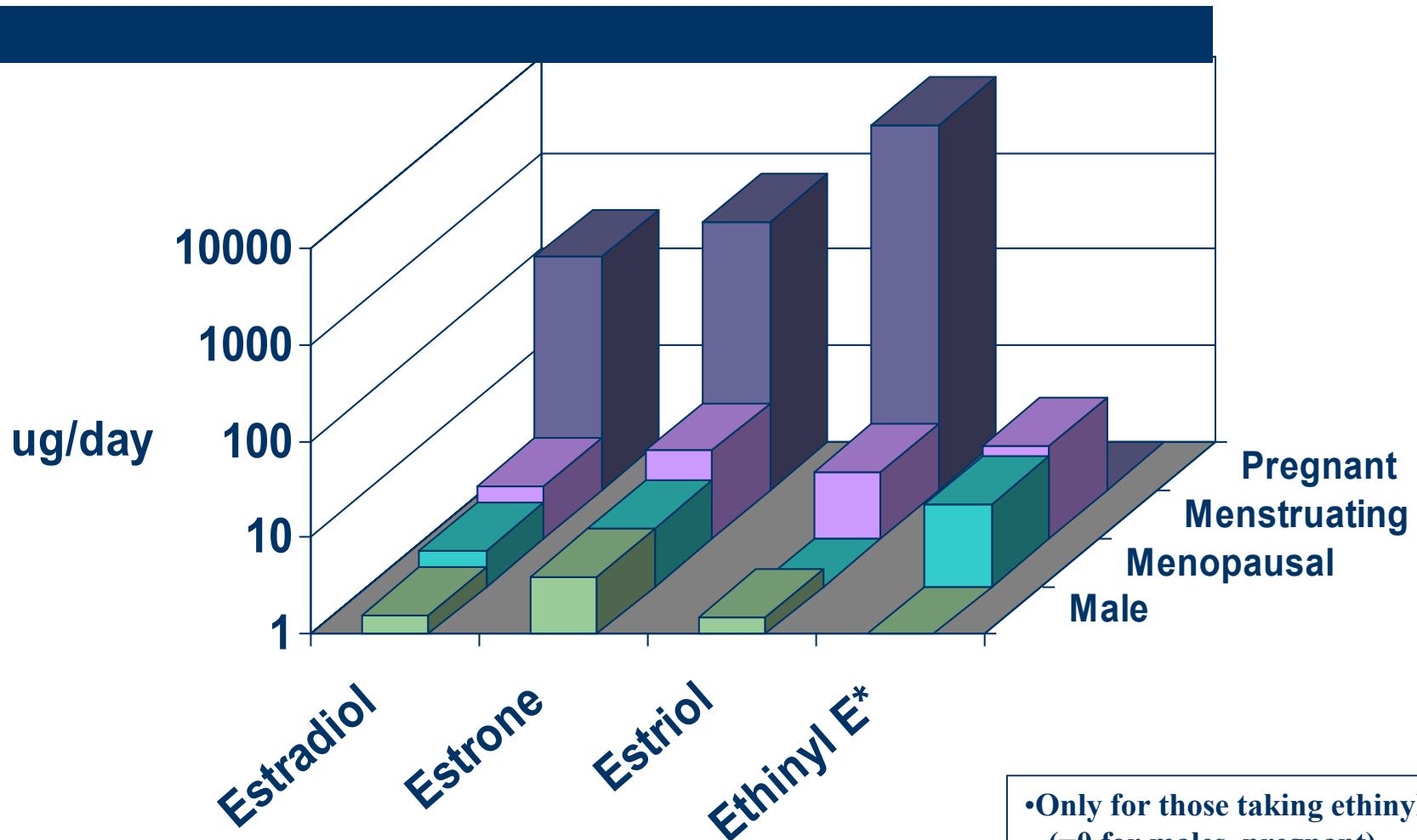
estrone



estriol



Amount of Estrogens Excreted



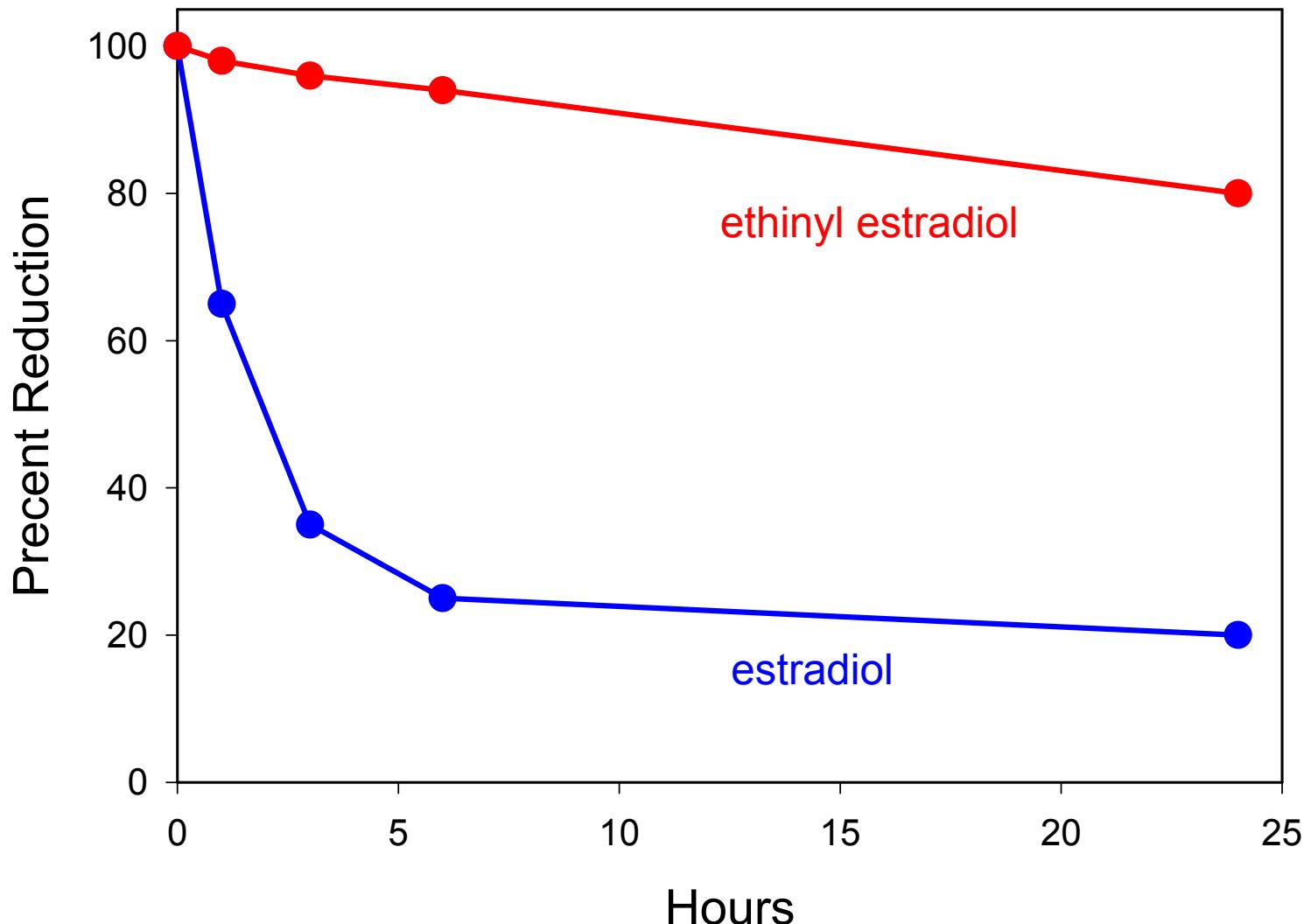
•Only for those taking ethynodiol-3-one
 (=0 for males, pregnant)

STP Influent - Raw Sewage

- ❖ Estradiol ND – 50 ng/l
- ❖ Estriol, estrone ND – 100 ng/l
- ❖ Ethinyl estradiol ND – 10 ng/l

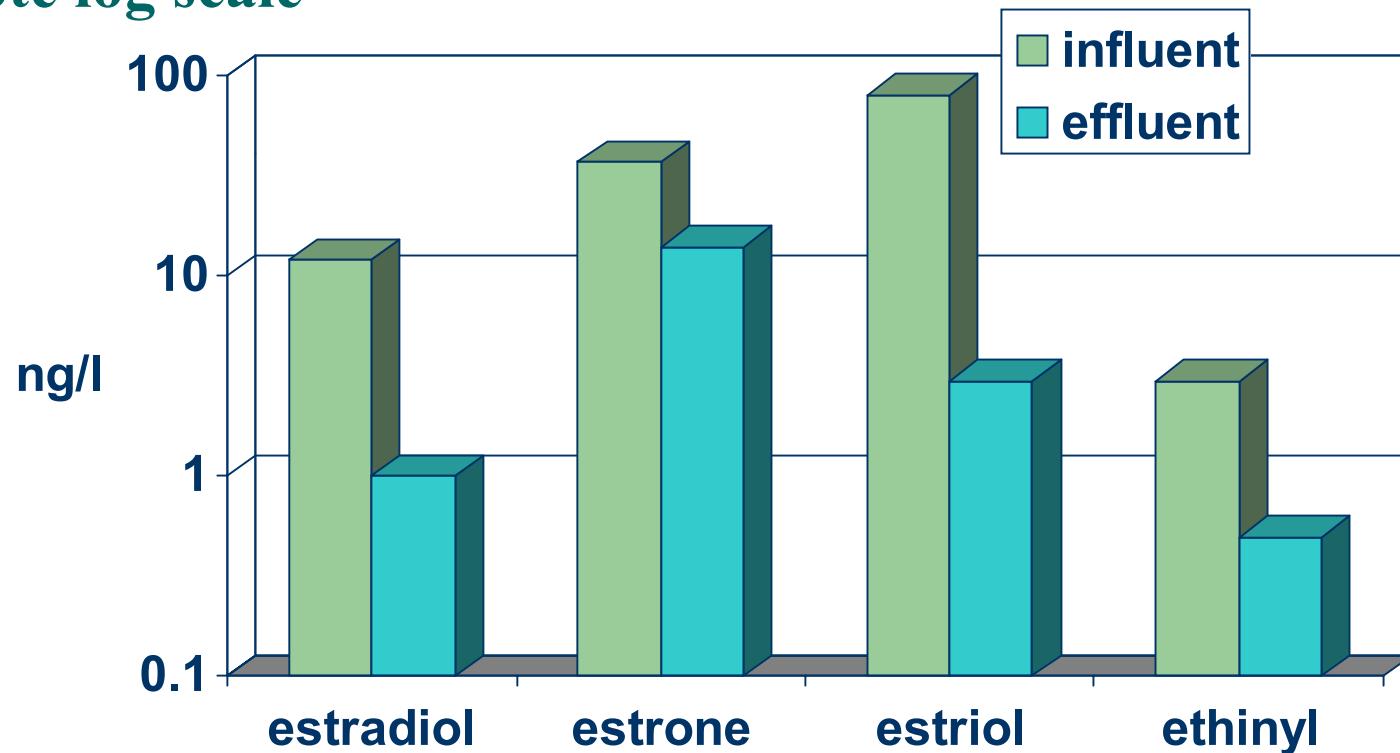
Estrogens in Activated Sludge

From 6 STPs in Tennessee (Layton, 2000)



Example STP Removal – Rome Italy

Note log scale



See Baronti, 2000

Biodegradation of Estrogens

- Aerobic
 - All biodegradable, ethinyl slowest
 - Nitrification may increase rate
- Anaerobic
 - Little known
 - Little biodegradation expected

Partition to Sludge, Sediments?

<u>EDC</u>	<u>log (Kow)</u>
Ethinyl estradiol	4.2
Estradiol	3.9
Estrone	3.4
Estriol	2.8

No sludge, sediments field data to date

Overall Impact of Various EDCs in STPs (Johnson, 2001)

<u>Chemical</u>	<u>Estradiol Equiv. (in vivo studies)</u>	<u>Level of Concern</u>
Ethinyl estradiol	12	High
Nonyl-, octyl-phenol	2 – 20	Moderate
Estrone	2.5	Moderate
Estradiol	1.0	Moderate
Estriol	0.02	Lowest
APEs, APECs, CAPEs	?	Low?

Summary

- Current limited data
 - Aerobic biodegradation produces estrogenic alkylphenolics in STPs
 - No evidence of destruction of alkylphenolics in STPs
 - Steroid hormones are aerobically biodegradable
 - Retention time in STP appears to be short
 - Sludge will accumulate low MW alkylphenolics and hormones
- Need detailed studies of EDC fate within the STP
- Are other sewage treatment systems removing EDCs?
 - Septic systems?
 - Small community treatment, constructed wetlands?

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